A Modern Definition of Mediastinal Compartments

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Abstract: Division of the mediastinum into compartments is used to help narrow the differential diagnosis of newly detected mediastinal masses, to assist in planning biopsy and surgical procedures, and to facilitate communication among clinicians of multiple disciplines. Several traditional mediastinal division schemes exist based upon arbitrary landmarks on the lateral chest radiograph. We describe a modern, computed tomography-based mediastinal division scheme, which has been accepted by the International Thymic Malignancy Interest Group as a new standard. This clinical classification defines a prevascular (anterior), a visceral (middle), and a paravertebral (posterior) compartment, with anatomic boundaries defined clearly by computed tomography. It is our intention that this definition be used in the reporting of clinical cases and the design of prospective clinical trials.

Key Words: Mediastinum, Compartments, CT.

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The mediastinum is an intricate segment of the thorax that contains vital intrathoracic structures such as the heart and great vessels, trachea and main bronchi, esophagus, thymus, venous and lymphatic structures, and nerve tissue. As dividing the mediastinum into specific compartments aids in the generation of differential diagnoses at initial presentation and facilitates surgical treatment plans, several different classification systems have been developed in the past by anatomists, clinicians, and radiologists. However, these existing schemes represent arbitrary nonanatomical divisions of the thorax based largely on the lateral chest radiograph. The lack of a computed tomography (CT)-centric scheme is problematic as the diagnosis, work-up (including biopsy approach), and formulation of treatment strategies are now determined by CT findings and not by chest radiography.

The International Thymic Malignancy Interest Group (ITMIG) has an established process to develop international standards in the realm of mediastinal disease; this method was applied to create a practical CT-based division of the mediastinum. First, ITMIG analyzed the existing literature regarding mediastinal compartments. Particular attention was paid to a mediastinal classification system based on transverse CT images recently proposed by the Japanese Association for Research of the Thymus (JART) in order to facilitate differential diagnosis of mediastinal lesions.[1] This model, which was derived from a retrospective analysis of 445 nonconsecutive pathologically proven mediastinal lesions, divides the mediastinum into four compartments. Based on discussions with experts in the field, ITMIG has modified the JART model; following the ITMIG process for standards, this proposed modification was extensively reviewed and subsequently adopted by ITMIG members. In this article, we describe this new, anatomically based mediastinal compartment system that can be used to accurately localize mediastinal lesions and formulate focused differential diagnoses.

METHODS

The process used in the development of this document was designed to represent a consensus within the community of clinicians and researchers interested in the divisions of the mediastinum and mediastinal diseases. A multidisciplinary group of 45 experts in thoracic surgery, oncology, diagnostic radiology, and pathology was surveyed regarding their preference for a 3-compartment or a 4-compartment model. A core workgroup (E.M.M., B.W.C., and F.C.D.) analyzed this data, reviewed the existing literature regarding mediastinal classification schemes, and drafted a proposed CT-based compartment model. This proposal was then refined by an extended workgroup (N.T., F.Y.B., M.L.R., J.N., and P.M.B.). The document was distributed to all members of ITMIG for comments and revised again. The final document was approved and adopted as an ITMIG standard by ITMIG members.

MEDIASTINAL COMPARTMENTS: A MODERN SYSTEM

Background

Numerous methods for classifying the mediastinal compartments have been published, the most common of

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which include the Shields' classification scheme[2] used in clinical practice and the traditional, Fraser and Pare, Felson, Heitzman, Zylak, and Whitten models[3–8] used in radiologic practice. However, differences in terminology and methods between these schemes have resulted in confusion among physicians. Additionally, because traditional models are based on the lateral chest radiograph, some mediastinal abnormalities cannot be reliably localized to a specific compartment, as considerable overlap exists.

As mediastinal lesions are optimally evaluated with cross-sectional imaging techniques, principally CT and MRI, accurate localization of the origin of the lesion and the extent of disease are crucial. It is only recently that a CT-based classification scheme for division of the mediastinal compartments has been proposed.[1] A universally adopted scheme is particularly relevant because a growing number of mediastinal abnormalities are detected by CT studies performed for screening and other purposes.[9] Therefore, consensus regarding a standardized method for dividing the mediastinum into specific compartments based on CT imaging is necessary in order to appropriately describe mediastinal lesions and formulate relevant differential diagnoses.

Number of Compartments

In constructing a CT-based definition of mediastinal compartments, one of the most important decisions involved the number of specific compartments to include in the system. Classification schemes have traditionally divided the mediastinum into three or four compartments, depending on whether a superior mediastinal compartment is distinguished or not. Most 4-compartment models include superior, anterior, middle, and posterior divisions, whereas the 3-compartment models describe only anterior, middle, and posterior divisions. Both models have strengths and weaknesses.

Advantages of a 4-compartment CT model include the similarity to established anatomic and radiologic 4-compartment models, the efficacy of such a system as demonstrated by the CT-based classification system proposed by JART, and the fact that the majority of thyroid goiters are typically located within the superior mediastinum. Disadvantages of a 4-compartment CT system include increased complexity, the general perception that most clinicians and radiologists do not use the existing 4-compartment schemes,[10] and several nonanatomic features. For example, the division between the superior and inferior (anterior, middle, and posterior) compartments is completely artificial and nonanatomic, as infectious and inflammatory processes, and tumors may freely spread to both sections without being restricted by fascial planes. Furthermore, posterior neurogenic tumors do not respect this arbitrary division. This nonanatomic boundary makes implementation and dissemination of any 4-compartment model difficult.

Advantages of a 3-compartment CT model include the similarity to the published anatomic, clinical, and radiologic 3-compartment models currently used, less complicated design, and the fact that specific compartmental boundaries are established along true anatomic planes. The primary disadvantage of the 3-compartment model is that merging the superior and anterior mediastinal compartments may not result in adequate separation of entities that occur in each of these locations. However, the benefit of distinguishing a separate superior compartment arises primarily by separating thyroid goiters from other anterior mediastinal tumors.[1] In actual practice, this is rarely a clinical dilemma since a thyroid goiter can usually be reliably identified on CT. Thus, in the era of CT, the advantage of having a separate superior mediastinal compartment decreases.

Among the surveyed multidisciplinary group of 45 experts, 72% preferred the 3-compartment model, 23% preferred the 4-compartment model, and 5% did not have a preference. Reasons why the participants chose one model over the other included optimal distinction of disease entities in 67%, similarity to what they currently use in 63%, because it is more anatomic in 53% and because it is easier to use in 48%.

Based on this feedback given by this group, a 3-compartment model was selected as the backbone for the CT-based classification scheme proposed by ITMIG.

Localization of Mediastinal Abnormalities

Because establishing a presumptive clinical diagnosis is extremely valuable in guiding the work-up and treatment of a patient with a mediastinal mass, having a reliable way to identify the origin of a lesion is important. Sometimes very large mediastinal lesions extend from one compartment to another, making it hard to identify the site of origin. There are two tools that are helpful in deciphering the compartment from which the tumor originated. The first is the "center method." In this method, the center of a mediastinal lesion (defined as the center point of the lesion on the axial CT image showing the greatest size of the lesion) localizes the abnormality to a specific compartment. In the JART study, this method resulted in classification of all 445 mediastinal masses to specific compartments.[1] The second tool is the "structure displacement tool." Very large mediastinal masses can displace organs from other compartments, usually those that abut the compartment from which the tumor originated. For example, a very large anterior mediastinal mass may displace organs of the middle mediastinal compartment such as the trachea or the heart posteriorly. ITMIG recommends that both of these methods be used to localize mediastinal abnormalities on CT scans.

ITMIG Definition of Mediastinal Compartments

We propose a 3-compartment model of the mediastinum including prevascular (anterior), visceral (middle), and paravertebral (posterior) compartments, as mediastinal compartment boundaries and the anatomic structures they contain can be readily identified on CT (Fig. 1 and 2).

In the proposed CT-based classification system, we recommend the following boundaries of the prevascular compartment: (1) superiorly—the thoracic inlet, (2) inferiorly—the diaphragm, (3) anteriorly—the sternum, (4) laterally—the parietal mediastinal pleura, and (5) posteriorly—the anterior aspect of the pericardium as it wraps around in a curvilinear fashion (thus any vessels contained within the pericardium are located in the middle mediastinum) (Table 1). Based on these landmarks, the major contents of the prevascular compartment include the thymus, fat, lymph nodes, and the left

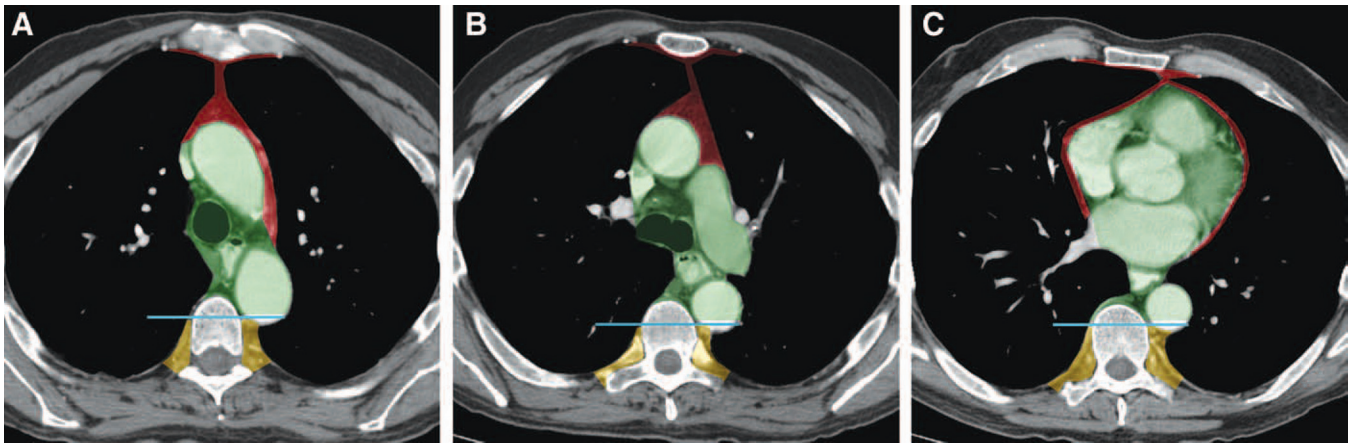

FIGURE 1. Coned-down contrast-enhanced axial CT images slightly below the aortic arch (*A*), at the level of the left pulmonary artery (*B*), and at the level of the left atrium (*C*) demonstrate the proposed classification scheme. Red, prevascular compartment; green, visceral compartment; yellow, paravertebral compartment; blue line, visceral–paravertebral compartment boundary line.

brachiocephalic vein. Therefore, the most common masses in the prevascular compartment include thymic abnormalities (cysts, hyperplasia, and malignancies such as thymoma, thymic carcinoma, and neuroendocrine tumors); germ cell neoplasms; lymphoma; metastatic lymphadenopathy; and intrathoracic goiter (Fig. 3*A*). Posterior and inferior displacement of the vessels described as the posterior boundaries of the compartment by these lesions may be used to assign these mediastinal abnormalities to the prevascular compartment.

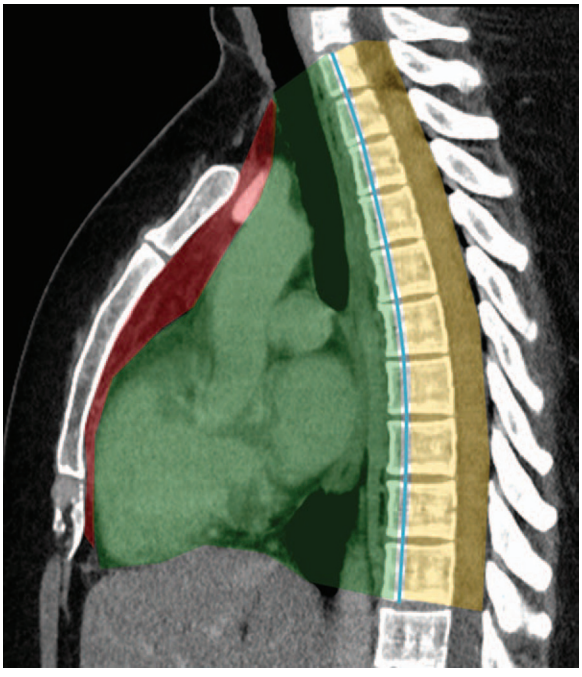

FIGURE 2. Sagittal reformatted image from contrast-enhanced CT demonstrates the proposed classification scheme. It is important to note that the prevascular compartment wraps around the heart and pericardium in the visceral compartment. Red, prevascular compartment; green, visceral compartment; yellow, paravertebral compartment; blue line, visceral–paravertebral compartment boundary line.

The visceral compartment is defined by the following boundaries: (1) superiorly—the thoracic inlet, (2) inferiorly—the diaphragm, (3) anteriorly—the anterior aspect of the pericardium (which envelops the distal aspect of the superior vena cava, the proximal aspect of the ascending aorta and lateral rim of the aortic arch, and the intrapericardial pulmonary arteries), and (4) posteriorly—a vertical line connecting a point on the thoracic vertebral bodies 1 cm posterior to the anterior margin of the spine (visceral–paravertebral compartment boundary line) (Table 1). This vertical line was selected as the posterior boundary of the visceral compartment and the anterior boundary of the paravertebral compartment because most neoplasms in the latter compartment are neurogenic tumors that arise from dorsal root ganglia/neurons adjacent to the intervertebral foramina. The major contents of the visceral compartment fall into two main categories: (1) a vascular category (i.e., heart, superior vena cava, ascending thoracic aorta, aortic arch, and descending thoracic aorta, intrapericardial pulmonary arteries, and the thoracic duct) and (2) the trachea, carina, and esophagus, which share an embryological origin (the endoderm) as well as lymph nodes. In the JART description, the middle compartment did not include the heart and great vessels[1]; in contrast, we suggest that all structures within the pericardium be included in the visceral compartment. We consider structures such as the extrapericardial pulmonary arteries and veins to be pulmonary and not mediastinal structures. The majority of abnormalities in the visceral compartment include lymphadenopathy (related to lymphoma or metastatic disease), foregut duplication cysts, tracheal lesions, and esophageal tumors (Fig. 3*B*). Additionally, lesions of the heart, pericardium (e.g., pericardial cyst), and great vessels (e.g., aortic aneurysm) may also be encountered in this compartment (Fig. 3*C*).

The paravertebral compartment is defined by the following boundaries: (1) superiorly—the thoracic inlet, (2) inferiorly—the diaphragm, (3) anteriorly—the visceral compartment, and (4) posterolaterally—a vertical line along the posterior margin of the chest wall at the lateral aspect of the

TABLE 1. ITMIG Definition of Mediastinal Compartments

Compartment	Boundaries	Major Contents
Prevascular	*Superior*: Thoracic inlet *Inferior*: Diaphragm *Anterior*: Sternum *Lateral*: Parietal (mediastinal) pleural reflections; lateral margin of the bilateral internal thoracic arteries and veins, and superior and inferior pulmonary veins *Posterior*: Anterior aspect of the pericardium, which lies along the anterior margin of the superior vena cava, ascending aorta, and the lateral rim of the aortic arch, superior and inferior pulmonary veins	Thymus Fat Lymph nodes Left brachiocephalic vein
Visceral	*Superior*: Thoracic inlet *Inferior*: Diaphragm *Anterior*: Posterior boundaries of the prevascular compartment *Posterior*: Vertical line connecting a point on each thoracic vertebral body at 1 cm posterior to its anterior margin	Nonvascular: Trachea, carina, esophagus, lymph nodes Vascular: Heart, ascending thoracic aorta, aortic arch, descending thoracic aorta, superior vena cava, intrapericardial pulmonary arteries, thoracic duct
Paravertebral	*Superior*: Thoracic inlet *Inferior*: Diaphragm *Anterior*: Posterior boundaries of the visceral compartment *Posterolateral*: Vertical line against the posterior margin of the chest wall at the lateral margin of the transverse process of the thoracic spine	Paravertebral soft tissues

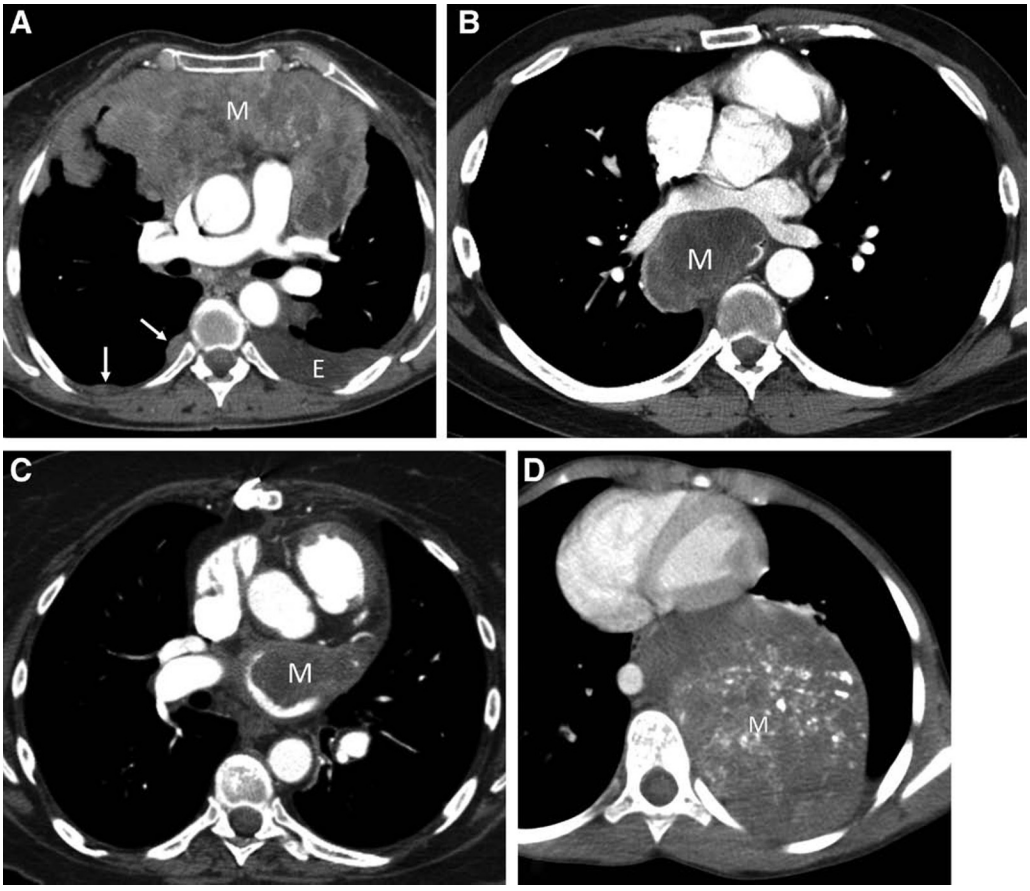

FIGURE 3. Representative examples of mediastinal masses. (*A*) Coned-down contrast-enhanced axial CT image shows a large heterogeneous mass (M) in the prevascular compartment consistent with a biopsy-proven thymoma. Note the posterior displacement of the heart and great vessels, confirming its anterior location. A left pleural effusion (E) and right pleural nodules (arrows) represent pleural dissemination. (*B*) Coned-down contrast-enhanced axial CT image shows a low attenuation mass (M) located between the left atrium and the thoracic spine, confirming its location in the visceral compartment. Endoscopic biopsy revealed esophageal cancer. (*C*) Coned-down contrast-enhanced axial CT image shows a low attenuation mass (M) located within the left atrium in this patient with an angiosarcoma. The intracardiac location of this lesion confirms its location in the visceral compartment. (*D*) Coned-down contrast-enhanced axial CT image shows a large mass (M) with calcifications in the left mediastinum. The mass displaces organs of the visceral compartment such as the heart anteriorly and the central portion of the lesion is localized to the paravertebral region; thus the origin of this mass is in the paravertebral compartment. CT-guided biopsy demonstrated ganglioneuroma.

transverse processes (Table 1). As the major contents of the paravertebral compartment include the thoracic spine and paravertebral soft tissues, most abnormalities in this region are neurogenic tumors arising from the dorsal root ganglia/neurons adjacent to the intervertebral foramina (Fig. 3*D*). Additionally, paravertebral lesions related to infection and trauma may also be encountered in this compartment.

CONCLUSION

The proposed mediastinal division is based on boundaries identifiable on routine cross-sectional imaging, principally CT, and at surgery. Because of the increasing number of patients in whom a mediastinal abnormality is first discovered on CT, and because of its simplicity, this division should be straightforward and can be adopted by clinicians in multiple domains. We anticipate that this system will improve tumor localization, help generate a focused differential diagnosis, and assist in tailoring biopsy and treatment plans. In addition, this universal system should facilitate communication among surgeons, oncologists, radiologists, and pathologists worldwide, with the added benefit of ultimately helping to create meaningful prevalence studies across institutions.

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